Value of Medical Innovation in the United States: 1960-2000

SPECIAL ARTICLE

The Value of Medical Spending in the United States, 1960–2000

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ABSTRACT

BACKGROUND

The increased use of medical therapies has led to increased medical costs. To provide insight into the value of this increased spending, we compared gains in life expectancy with the increased costs of care from 1960 through 2000.

METHODS

We estimated life expectancy in 1960, 1970, 1980, 1990, and 2000 for four age groups. To control for the influence of nonmedical factors on survival, we assumed in our base-case analysis that 50 percent of the gains were due to medical care. We compared the adjusted increases in life expectancy with the lifetime cost of medical care in the same years.

RESULTS

From 1960 through 2000, the life expectancy for newborns increased by 6.97 years, lifetime medical spending adjusted for inflation increased by approximately $69,000, and the cost per year of life gained was $19,900. The cost increased from $7,400 per year of life gained in the 1970s to $36,300 in the 1990s. The average cost per year of life gained in 1960–2000 was approximately $31,600 at 15 years of age, $53,700 at 45 years of age, and $84,700 at 65 years of age. At 65 years of age, costs rose more rapidly than did life expectancy: the cost per year of life gained was $121,000 between 1980 and 1990 and $145,000 between 1990 and 2000.

CONCLUSIONS

On average, the increases in medical spending since 1960 have provided reasonable value. However, the spending increases in medical care for the elderly since 1980 are associated with a high cost per year of life gained. The national focus on the rise in medical spending should be balanced by attention to the health benefits of this increased spending.

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Advances in medical care have led to sustained increases in medical spending over time. Adjusted for inflation, annual medical spending per person has increased from approximately $700 in 1960 to more than $6,000 today, tripling as a share of the gross domestic product (GDP).[1] At least half this increase is a result of more care, not higher prices for existing care.[2]

An evaluation of whether increased medical spending is useful requires the valuation of the increase in care. The enormous growth in spending has led many to argue that the increasing costs are excessive.[3] Others, however, suggest that spending more may provide good value, whether measured in costs per year of life gained or in overall measures of economic benefit.[4-7] The vast literature on the cost-effectiveness of specific medical treatments and other interventions suggests that many (though certainly not all) medical treatments provide reasonable value.[8] However, there has been comparatively little effort to understand the value of the medical system as a whole: Is the increase in spending by more than a factor of eight worth it?

We addressed this question by examining how medical spending has translated into gains in survival. We measured the increase in medical spending from 1960 through 2000 and compared it with the number of additional years of life lived, focusing on the gains in life expectancy that were likely to be due to medical care. We assumed in our base case that 50 percent of improvements in longevity resulted from medical care. We also conducted sensitivity analyses using various assumptions about the proportion of life-expectancy gains that was attributable to health care.

Methods

We estimated life expectancies and the projected medical spending for four age groups in 1960, 1970, 1980, 1990, and 2000, according to the mortality rates and costs that prevailed in each year. For example, when calculating the lifetime costs (i.e., costs from birth) of health care for a newborn in 1960, we used the 1960 values for spending in all ages. In this way, we obtained an accurate picture of the medical system as it existed at each time, and we were able to explore how that picture changed over time.

Life Expectancy

Our data on life expectancy were based on U.S. life tables for 1959–1961, 1969–1971, 1979–1981, 1989–1991, and 2000.[9] For simplicity, we refer to the three-year periods by the middle year (1960, 1970, 1980, 1990). To estimate changes in life expectancy according to cause, we used cause-deletion methods.[10] Specifically, we obtained the rates of death from each cause in 1960 according to age. We then added the age-specific change in the mortality rate between 1960 and 2000 for a particular cause to the age-specific overall mortality rate in 1960 and calculated the life expectancy according to the new mortality rate. The difference between the life expectancy calculated with the new mortality rate and the life expectancy in 1960 was considered to reflect the effect of that cause on life expectancy.

We assumed that a portion of the gains in life expectancy were related to medical care. Analyses aggregated from treatments clearly shown to be medically effective suggest that at least half the life-expectancy gains since 1950 are due to medical advances.[11-13] About 90 percent of the gains in life expectancy are attributable to improvements in the rates of death in infancy and the rates of death from cardiovascular disease. Prevailing estimates suggest that at least half the reduction in these rates are due to medical care.[4,14-23] We therefore assumed in our base case that 50 percent of the total gains in life expectancy were due to medical care.

We examined this assumption by considering the importance of two causes of death that are unlikely to be due to changing medical treatment. The first was death attributable to smoking. Rates of smoking among adults fell from 42 percent in 1960 to 22 percent in 2000. To estimate the changes in life expectancy that were attributable to reduced rates of smoking, we constructed an alternative time series for mortality in 1970, 1980, 1990, and 2000, assuming that smoking rates were fixed at 1960 levels — in essence, assuming that none of the decline in the rate of smoking was due to medical treatment. Data on the prevalence of smoking were from the National Health Interview surveys for 1965–2000[24] and from a survey of adolescents in California.[25] Because the surveys did not collect information on smoking until 1965, the ratio of per capita cigarette use in 1960 was compared with that for 1965 to extrapo-

late the prevalence data before 1965.[26] By combining the prevalence of smoking with the relative risk of death for smokers,[27] we could estimate the contribution of reduced rates of smoking to increased longevity.

The second cause we investigated was the rate of death from external factors: accidents (most commonly involving motor vehicles), suicide, and homicide. The rates of death from external causes have declined by 44 percent since 1960. Although this decline is partly related to medical care (better emergency room care, for example), trends in survival are likely to reflect other factors to a far larger degree.[20] To estimate the effect of changes in the rate of death from external causes, we assumed that the rate was the same in 1970, 1980, 1990, and 2000 as it was in 1960.

The effect of medical care on improvements in health is uncertain. We therefore performed sensitivity analyses on the percentage of gains in life expectancy that was assumed to be due to medical care.

MEDICAL SPENDING

We obtained data on medical spending according to age from Meara et al.[28] These researchers estimated spending for five years for which health-expenditure surveys were available: 1963, 1970, 1977, 1987, and 2000. Spending was defined as total medical costs; we did not consider the indirect costs of medicine, such as improvements in productivity. We interpolated and extrapolated the data by using national spending trends to estimate age-specific spending in 1960, 1970, 1980, 1990, and 2000. Lifetime costs were calculated with the use of the probability of survival to each age. All spending was adjusted to 2002 dollars with the use of the GDP deflator and was discounted at a rate of 3 percent. The discounting, combined with the fact that not all people live to an advanced age, meant that the current value of lifetime spending at a younger age need not have exceeded the current value of spending at an older age.

VALUE OF MEDICAL CARE

To measure the value of care, we divided the change in spending from one decade to the next (incremental costs) by the change in life expectancy from one decade to the next (incremental health benefits). We calculated the number of dollars spent per year of life gained during the entire life span (i.e., from birth to death) for 1960, 1970, 1980, 1990, and 2000 individually and for the four-decade period as a whole. We also estimated the costs per year of life gained between 15 years of age and death, 45 years of age and death, and 65 years of age and death by including the medical costs incurred and the increase in life expectancy after each age. A lower ratio of dollars spent to years of life gained indicated a better value (i.e., less money paid for each one-year increase in life expectancy).

RESULTS

The remaining life expectancy for four age groups (newborn and 15, 45, and 65 years of age) is listed in Table 1. The life expectancy for newborns increased by 6.97 years between 1960 and 2000. At 3.12 years, the increase in life expectancy between 1970 and 1980 was the largest increase during any decade. The increase was 0.86 year between 1960 and 1970, 1.5 years between 1980 and 1990, and 1.49 years between 1990 and 2000. The mortality rate fell between 1960 and 2000 for each age group.

The causes of the increases in life expectancy for newborns between 1960 and 2000 are shown in Table 2. Of the 6.97-year increase in life expectancy, 4.88 years (70 percent) resulted from a re-

Table 1. Life Expectancy According to Age Group and Year, 1960–2000.

Age	Life Expectancy					Cumulative Change (1960–2000)
	1960	1970	1980	1990	2000	
	years					
Newborn	69.90	70.76	73.88	75.37	76.87	6.97
15 Yr	57.33	57.69	60.19	61.38	62.62	5.29
45 Yr	29.50	30.12	32.27	33.44	34.38	4.88
65 Yr	14.39	15.00	16.51	17.28	17.86	3.47

duced rate of death from cardiovascular disease. An additional 1.35 years (19 percent) resulted from a reduced rate of death in infancy. A reduced rate of death from external causes led to an additional increase of 0.36 year (5 percent). The reduction in the rate of death from smoking (included in the rate of death from cardiovascular disease and other causes) led to an increase in life expectancy of 1.1 years (16 percent) (data not shown). The combined effect of reduced rates of death from external causes and smoking, 21 percent, is less than the increase in longevity of 50 percent that we attributed to nonmedical factors.

Estimates of the present value of medical spending for each of the four age groups, calculated with the use of age-specific spending rates that prevailed in each year, are listed in Table 3. In 1960, lifetime spending from birth was about $14,000 per person. That amount had increased to more than $83,000 by 2000, an increase by a factor of nearly six. At older ages, medical spending increased even more between 1960 and 2000 — by a factor of more than 13 for people 65 years of age or older, for example.

The lifetime incremental costs per year of life gained, based on the assumption that 50 percent of such increases were due to medical care, are shown in Figure 1. From birth, during the entire period from 1960 through 2000, an average of $19,900 was spent per year of life gained. Costs per year of life gained were lower in the first two decades than in the third and fourth decades but costs per year of life for newborns never exceeded $40,000 per year. At older ages, there were substantial increases in the cost of each additional year of life gained. For example, the average cost per year of life gained at 65 years of age was about $84,700 during the entire 1960–2000 period but rose from $75,100 between 1960 and 1970 to $145,000 between 1990 and 2000.

We used sensitivity analyses to examine how varying the proportion of increases in life expectancy gains assumed to be due to medical care would affect the estimates of cost-effectiveness (Fig. 2). If 25 percent of the gains in life expectancy were due to health care, then the average cost per year of life gained between 1960 and 2000 would have ranged from $39,800 at birth to $169,400 at 65 years of age. According to this scenario, each one-year increase in life expectancy cost more than $70,000 between 1990 and 2000 for each age group. Conversely, if 75 percent of the increase in life expectancy were due to health care, then the average cost per year of life gained between 1960 and 2000 would have ranged from $13,300 for newborns to $56,500 for people 65 years of age or older.

Table 2. Causes of Increases in Life Expectancy among Newborns, 1960–2000.*

Cause	Increase in Life Expectancy	Relative Contribution
	yr	%
Reduction in rate of death from cardiovascular disease	4.88	70
Reduction in rate of death in infancy	1.35	19
Reduction in rate of death from external causes	0.36	5
Reduction in rate of death from pneumonia or influenza	0.28	4
Reduction in rate of death from cancer	0.19	3
Total	6.97	100

* The data do not sum to the total because of slight increases in the rates of death from other causes (not listed) and because of rounding.

DISCUSSION

Medical spending has increased at more than 10 percent per year for most of the past four decades, largely as a result of the development and widespread use of new medical techniques.[2] This dramatic increase in spending has contributed to political pressure to restrain costs.[3] Yet one of the most important questions remains unanswered: What is the value of this medical spending? We attempted to answer that question by comparing the trends in spending with the trends in life expectancy. During the period from 1960 through 2000, we estimated that increased spending on health care at birth resulted in an average cost of $19,900 per year of life gained. In analyses including spending and the increase in life expectancy for people 65 years of age, the average cost per additional year of life was about $84,700.

The value of a year of life as used in medical decision-making (known as the value of a statistical life) is the subject of some debate. Viscusi and Aldy[29] estimated the value of a statistical life for people of working age at approximately $7 million. For a person who is roughly 45 years old and thus has a remaining life expectancy of 30 years, the value is more than $200,000 per year of life re-

Table 3. Present Value of Average Medical Spending per Person According to Age Group and Year.*

Age	Average per Capita Spending					Cumulative Change (1960–2000)
	1960	1970	1980	1990	2000	
				$		
Newborn	13,943	25,528	37,085	56,120	83,307	69,364
15 Yr	18,700	32,704	47,155	69,457	102,490	83,790
45 Yr	17,141	35,266	63,275	100,983	148,014	130,873
65 Yr	11,495	34,526	69,819	116,097	158,549	147,054

* Values are expressed in 2002 U.S. dollars. Costs were discounted with the use of an interest rate of 3 percent. Because of this discounting and the fact that not everyone lives to an advanced age, the present value of lifetime spending at younger ages need not exceed the present value of spending at older ages.

maining.[7] Some studies recommend a value of $100,000 per year of life,[4,30] whereas the National Institute for Health and Clinical Excellence, whose analysis is used to inform decisions about health coverage by the British National Health Service, seems to use a value of £25,000 to £35,000 per year of life (roughly $50,000) as a general upper limit, though this is not specifically stated as policy.[31]

According to virtually any commonly cited value of a year of life, we found that if medical care accounts for about half the gains in life expectancy, then the increased spending has, on average, been worth it. However, the current trends are a cause for concern. There has been a sharp increase in the cost per additional year of life gained during the past two decades, primarily among the elderly. Analyses focused on spending and on the increase in life expectancy beginning at 65 years of age showed that the incremental cost of an additional year of life rose from $46,800 in the 1970s to $145,000 in the 1990s. The former amount certainly reflects a good value, but the latter fails to meet many cost–benefit criteria. Furthermore, it appears that although the rate of increase in spending had stabilized, if not declined, by 2000 for the newborn and 15-year-old groups, this rate is substantially outpacing the rate of increase in life expectancy in older age groups. If this trend continues in the elderly, the cost-effectiveness of medical care will continue to decrease at older ages.

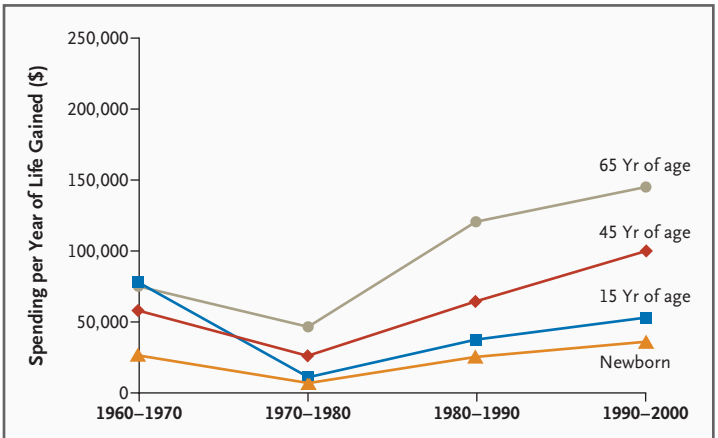

Figure 1. Longitudinal Trends in the Costs per Year of Life Gained in Four Age Groups.

Spending per year of life gained was defined by the change in spending over the decade divided by the change in expected years of life over the decade.

The reasons for the substantially increased cost per year of life gained in older age groups cannot be ascertained from our analyses, although other investigators have examined possible reasons.[3] One is that the "low-hanging fruit" (less expensive therapies such as antihypertensive medications) were picked first, and incremental advances thereafter have necessarily been more costly. Another is that relatively more care for elderly patients than for younger patients is palliative or residential, which results in increased spending for the elderly and does improve quality of life but may not improve longevity.

Clearly, not all improvements in the mortality rate resulted from medical spending, but we used a conservative method to estimate the percentage that did. Consistently with past analyses,[11-13] we assumed that only 50 percent of the reduction in the mortality rate was due to medical care. This assumption is likely to be reasonable, given our

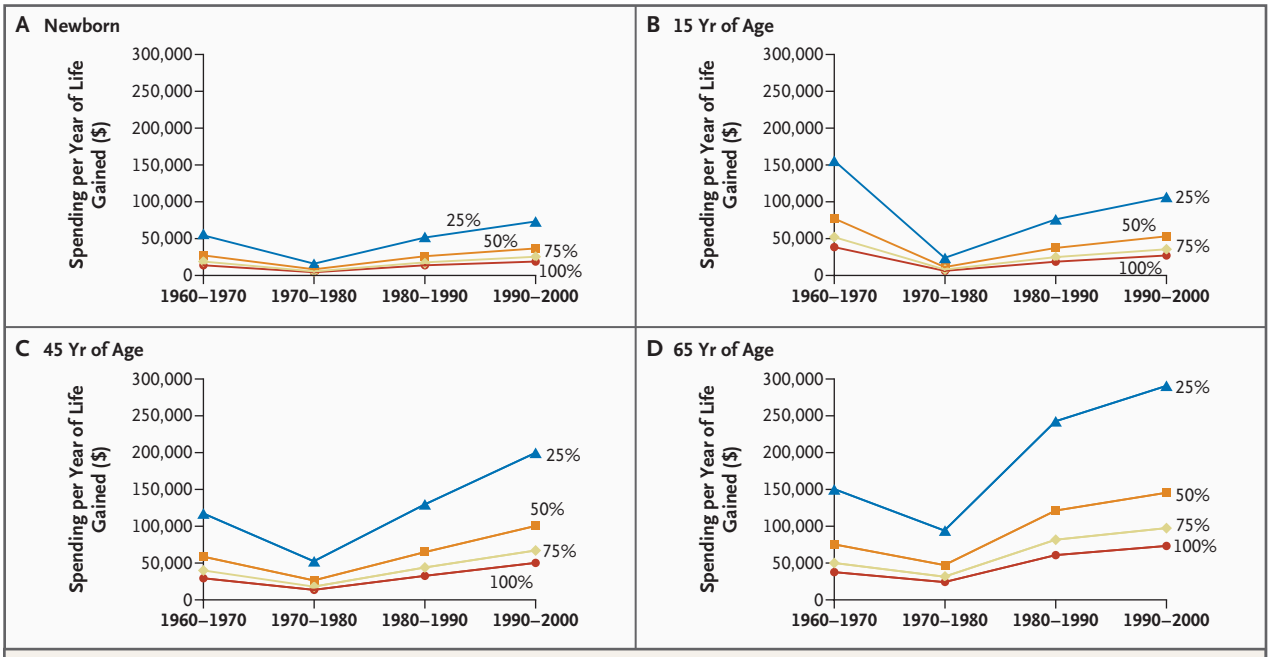

Figure 2. Results of Sensitivity Analyses of the Percentage of the Increase in Life Expectancy Assumed to Be Due to Medical Care from Birth (Panel A), from 15 Years of Age (Panel B), from 45 Years of Age (Panel C), and from 65 Years of Age (Panel D).

Spending per year of life gained was defined by the change in spending over the decade divided by the change in expected years of life over the decade.

finding that 90 percent of the increases in life expectancy during the past four decades have resulted from reductions in the rate of death from cardiovascular disease and death in infancy. Although reductions in the rate of death from cardiovascular causes are multifactorial, prior research has suggested that at least half the reductions in the rate have resulted from medical advances.[14-17] Among infants, more than half the reduction in the mortality rate between 1960 and 2000 resulted from a reduced rate of neonatal death among low-birth-weight infants (weighing <2500 g), which is due almost entirely to medical advances.[18,19,21-23]

To validate our assumption, we considered other factors that were unlikely to be the result of medical care. Reduced rates of death from external causes and death related to smoking together accounted for 21 percent of the increase in longevity, well below the 50 percent that we attributed to nonmedical factors. Even if only 25 percent of the gains in longevity were due to medical care, the value of medical care is reasonable, on average.

Our primary conclusion is that although medical spending has increased over time, the return on spending has been high. In considering health policy, the concern about high medical costs needs to be balanced by the benefits of the care received.

Our results contrast with the conclusions that are often drawn from international data. The United States spends more on health care than other countries do, with similar or poorer overall outcomes. Of course, differences in culture, lifestyle, and social systems may confound these international comparisons. Still, it is clear that the U.S. health care system is not as efficient as it could be,[32] and improving its efficiency is an important goal. However, our results suggest that the increase in spending is not solely attributable to an increase in inefficiency. Indeed, medical spending has increased at roughly the same rate in all countries.[2,33] Taken as a whole, the average return on the increased spending has been high.

One possible scenario for the future of health care is that the costs per year of life gained will continually increase, resulting in wasted resources. However, extrapolation of any kind is inherently uncertain, and particularly so for medical advances. The genetic revolution is opening new avenues for medical inquiry, and some very cost-effective therapies could emerge. In addition,

quality-improvement initiatives could increase the value of every dollar spent.

A number of limitations of our study should be mentioned. First, our estimate that 50 percent of the increase in longevity results from medical care is uncertain. Although reduced rates of death from tobacco use and from external causes accounted for only 21 percent of the increase in life expectancy, we did not consider all causes of changes in life expectancy that were due to nonmedical interventions. The most obvious omissions were the increased rate of obesity and the spread of acquired immunodeficiency syndrome, each of which results in worsened health. Second, our analysis was based on mortality alone, not on changes in the quality of life. Consistent data on the quality of life were not available for the period from 1960 through 2000. However, studies suggest that there were substantial improvements in the quality of life during this period, especially among the elderly.[13,34] Thus, our estimates are likely to have understated the value of medical spending. Finally, although we excluded gains in life expectancy that were due to nonmedical interventions, we did not exclude their associated costs, owing to the difficulty of disaggregating them from the overall costs of health care. This resulted in the overstatement of cost increases and thus the understatement of the value of medical advances.

In conclusion, although medical spending has increased substantially during the past 40 years, the money spent has provided good value. However, temporal trends suggest that the value of health care spending is decreasing over time, particularly for older age groups. We need to continue tracking trends in health care spending and its benefits to ensure that resources are allocated wisely. Such efforts should focus on specific diseases in order to provide a more detailed picture of the value of health care both within disease categories and across a spectrum of common diseases over time. Also, the United States should modify its system of tracking the health sector to include a measure of population health in addition to spending, so that policymakers and the public have an informed picture of the benefits obtained for the money spent.

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